

# EXECUTIVE SUMMARY

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## DOCUMENT DESCRIPTION

This Remedial Investigation/Feasibility Study (RI/FS) document consists of two sections. The RI section presents the results of the investigations conducted at the Tourtelot Project Site in Benicia, California (Project Site). These investigations characterize ordnance and explosives (OE) and chemical (non-OE) impacts at the Project Site. The investigative work performed led to the identification of several areas of interest where site activities may have impacted fill materials, native soil, bedrock, sediments in wetland areas, surface water, and groundwater.

The FS section is based upon the data collected in the RI. The FS identifies and evaluates potential remedial alternatives for the Project Site and presents the recommended alternative. Eight alternatives were developed and screened for effectiveness, implementability, and cost. Five of these alternatives were retained for further screening, focusing on the nine criteria contained in regulatory guidance (overall protection of human health and the environment; compliance with regulatory requirements; long-term effectiveness and permanence; short-term effectiveness; reduction in toxicity and mobility; or volume; implementability; cost; regulatory acceptance; and community acceptance). In addition, this RI/FS assesses, through screening level assessments, the human health and ecological risks associated with the impacts identified in the RI. The RI/FS was prepared to comply with requirements set forth in the *Imminent and/or Substantial Endangerment Determination and Remedial Action Order (Docket No. I/SE 98/99-011)* (the "Order") issued on June 1, 1999, by the California Environmental Protection Agency (Cal/EPA), Department of Toxic Substances Control (DTSC).

## PROJECT SITE

The 220-acre Project Site includes features known as the South Valley, Ridge, North Valley, and the Unit D-1 Parcel. Figure ES-1 shows the locations of these features and the identified areas of interest. The Project Site has been fenced with controlled access and is patrolled by a security firm since 1996.

## BACKGROUND

From 1849 through 1958, the United States acquired, by lease, license, or in fee, over 2,700 acres in Benicia, Solano County, California, for the Benicia Arsenal. The Benicia Arsenal began at the shore of the Carquinez Strait and extended northward. Over its 100-year history, the Benicia Arsenal was used as a principal depot for ordnance storage, issuance, and transshipment. The Tourtelot Property (which is contained within the Project Site) consists of approximately 200 acres of undeveloped grassland northwest of the former Benicia Arsenal. The Tourtelot Property was leased to the U.S. Army from 1944 to 1960; for that period of time, the property was part of the Benicia Arsenal. Between 1945 and 1960, the U.S. Army conducted several Arsenal-related activities on the property, including

artillery testing, demilitarization, and demolition of damaged and obsolete munitions.

After the Benicia Arsenal was closed in 1964, the Tourtelot Property changed hands, and plans for private residential development were initiated. In 1990, initial grading activities were conducted on the Project Site. Soils were cut from the Ridge, the McAllister Drive Land Bridge was constructed, and the Unit D-1 lots were graded. In 1996, concrete-filled howitzer shells and live ordnance were discovered. This finding prompted the developer of the property, Granite Management Corporation (Granite), and the U.S. Army Corps of Engineers (USACE) to characterize the site for OE and soil and groundwater impacts.

## **INVESTIGATIONS PERFORMED**

The first part of this document presents the results of the historical and geotechnical investigations at the Project Site. USACE conducted historical investigations of the former Benicia Arsenal, including the Project Site, in 1994, 1996, and 1999 (see the March 1994 Archives Search Reports (ASRs), the May 1997 Supplemental ASR, and the 1999 Records Research Report). In addition, USACE performed an engineering evaluation/cost analysis (EE/CA) to evaluate potential OE and assess safety risks at the former Benicia Arsenal. A geophysical survey was conducted in 1996 over the entire Project Site, excluding the cut portion of the Ridge, the west portion of the South Valley, and the wetland area in the South Valley, to assess the distribution of metallic anomalies. An additional geophysical survey of select areas throughout the Project Site was conducted in 1999. A preliminary investigation of surface soil and surface water conducted in 1998 identified the presence of chemicals of interest (COIs) in soil at the Project Site.

The geophysical surveys conducted identified anomalies at the Project Site. The data collected from these surveys were used to perform OE clearances in August and December 1996 and to support a USACE OE investigation of the former Benicia Arsenal, including the Project Site and adjacent property, in March 1999. Additionally, in May 2000, an OE clearance of proposed excavation locations at the North Valley Military Landfill was conducted to facilitate the characterization of soil beneath the landfill. About one-half of the geophysical anomalies cleared from the North Valley Military Landfill were OE scrap. No OE was encountered.

As a result of previous clearances and investigations, a total of nine OE items related to site activities have been recovered from the Project Site. All nine items have been recovered from the South Valley and the south portion of the Ridge. No OE items have been recovered from the North Valley or on the slopes of the North Valley. All OE and OE scrap recovered from the Project Site, outside the demolition sites in the South Valley, were recovered at depths less than 2 feet below ground surface (bgs), except in two areas disturbed by grading activities. The absence of OE and OE scrap at depths greater than 2 feet bgs indicates that OE at the Project Site is likely to be buried at a shallow depth that is consistent with the historical use of the Project Site.

Four investigations were conducted between May 1999 and August 2000, primarily to evaluate the presence of chemicals in the areas of interest identified as being associated with site activities. The four investigations include the interim investigation, RI, data gaps investigation, and the removal action investigation. These investigations performed to date, with the exception of the removal action investigation, were performed using techniques to avoid metallic anomalies (ordnance avoidance techniques).

Data from these and the previous investigations were used to help define the nature and extent of OE and COIs at the Project Site to the extent possible based on ordnance avoidance techniques and to evaluate remedial action alternatives.

The Army's historic activities at the Project Site were conducted in the South Valley, the Ridge, and the North Valley. The results of the investigations are summarized by area of interest and feature below:

**TNT Strips - North Valley.** There are five linear features on the northern hillside of the North Valley, referred to as the TNT Strips. Trinitrotoluene (TNT) has been detected in the upper 2.5 feet of soil along the axis of the strips at concentrations exceeding 100,000 milligrams per kilogram (mg/kg) (i.e., 10 percent by weight) at 2 locations in 3 samples, out of a total of 84 samples collected along the axis of the strips within the upper 3 feet. Soil containing TNT at a concentration of 10 percent or greater is classified as OE. At a depth of approximately 10 feet bgs in the strips, TNT concentrations are typically non-detect or less than 16 mg/kg, the proposed remediation goal for TNT in residential areas. TNT concentrations also decrease significantly away from the axis of the strips. At a distance greater than 20 feet in the downslope direction and 10 feet in the upslope direction, TNT concentrations in the soil within the upper 4 feet are non-detect or less than 16 mg/kg.

Concentrations of TNT less than 200 mg/kg have been detected in isolated surficial soil samples northwest of the TNT Strips. Concentrations of TNT less than 100 mg/kg have also been detected sporadically in the surficial soil along the ridge top above the TNT Strips area near the Project Site boundary. TNT at 17 mg/kg or less has been detected in the soil/bedrock along the floor of the North Valley. Other COIs identified at the TNT Strips include unknown hydrocarbons, polynuclear aromatic hydrocarbons (PAHs), and dioxins/furans (combustion by-products).

**Howitzer Test Facility and Stockpile #3 - North Valley.** The Howitzer Test Facility was used to test gun barrels manufactured in Benicia by firing dummy/gravel-filled rounds into test tunnels. Low concentrations (less than 100 mg/kg) of petroleum hydrocarbons in the motor oil range, as well as other hydrocarbons (representing weathered fuels), have been detected in the near-surface soil in roads and other areas historically used for access and parking at the Howitzer Test Facility. The source of these petroleum hydrocarbons is unknown, but is thought to be related to historical practices of oiling roads and parking areas for dust suppression.

In addition, low concentrations (less than 20 mg/kg) of petroleum hydrocarbons in the motor oil range were detected at two locations at depths of up to 10 feet and 20 feet bgs, respectively. The source of these hydrocarbons is unknown. Other COIs detected at this site include benzene, toluene, and xylenes, which were detected at low concentrations (less than 0.0055 mg/kg) in one sample at 10 feet bgs in the vicinity of former Buildings 540 and 542. A low concentration of benzene (0.0018 mg/kg) was detected at one other nearby location at 20 feet bgs. 1,2,3-trichlorobenzene and 1,2,4-trichlorobenzene were also detected at low concentrations (less than 0.0016 mg/kg) in a near-surface sample in the same general area. These compounds are typically associated with petroleum hydrocarbons, oils, and/or lubricants.

Low concentrations (0.11 mg/kg or less) of PAHs and moderate levels (200 mg/kg or less) of petroleum hydrocarbons and unknown hydrocarbons were detected in samples from Stockpile #3.

**North Valley Military Landfill - North Valley.** Wood crates, pallet and packing materials, a crushed metallic structure, and OE scrap were found in this 0.33-acre area that the Army reportedly used as a landfill. Other hydrocarbons, volatile organic compounds (VOCs), two dioxins/furans, and one pesticide were detected in various soil samples in the fill material and at 2 feet below in the underlying soil. Estimated low concentrations of two explosive compounds (HMX at 0.26 micrograms per liter [ $\mu\text{g/L}$ ] and 2,4-dinitrotoluene [2,4-DNT] at 0.66  $\mu\text{g/L}$ ), other hydrocarbons (less than 200  $\mu\text{g/L}$ ), and one dioxin (OCDD at 260 picograms per liter [ $\text{pg/L}$ ]) were detected in grab groundwater samples collected from test pits excavated within the landfill. With the exception of the hydrocarbons, none of these compounds has been detected in the groundwater monitoring wells downgradient of the landfill.

**Ammunition Renovation/Primer Destruction Site and Stockpiles #1 and #2 - North Valley.** The Ammunition Renovation/Primer Destruction Site was an area where ordnance was inspected and refurbished and where ordnance primers were destroyed by burning in a cage. Low concentrations (typically less than 75 mg/kg) of petroleum hydrocarbons in the motor oil range, as well as other hydrocarbons, have been detected in both the near-surface and deeper soil (up to 10 feet bgs) toward the northwest end of the Ammunition Renovation/Primer Destruction Site. Petroleum hydrocarbons in the motor oil range (less than 100 mg/kg) were also detected at depth (30 feet bgs) in the northeast corner of the site. Although the source of the petroleum hydrocarbons in this portion of the North Valley is unknown, it is assumed that the source in the shallow soils is related to historical practices of oiling roads and parking areas for dust suppression.

Toward the southeast corner of the site, other petroleum hydrocarbons (up to 310 mg/kg) were detected in the near-surface soil. Petroleum hydrocarbons in the diesel range were detected in the same area in one sample at a concentration of 220 mg/kg and another at 630 mg/kg at depths of 22 feet bgs and 17.5 feet bgs, respectively. Two geophysical anomalies in this area have been interpreted as possible underground storage tanks (USTs) and associated piping, and are thought to represent the source of the impact.

Low concentrations of PAHs (0.46 mg/kg or less) and moderate levels of petroleum hydrocarbons (1,400 mg/kg or less) were detected in samples from Stockpiles #1 and #2.

**Dynamite Burn Site - Ridge.** Dynamite was reportedly destroyed by burning in this area. No COIs related to site activities were detected at this site. Analysis of the site grading activities indicate that soil from this area was placed in the McAllister Drive Land Bridge.

**Flare Site - South Valley.** This area was reportedly used to destroy flares by burning. Five metals related to these activities were identified in soil at the Flare Site. The metals and their maximum-detected concentrations are as follows: antimony (150 mg/kg), barium (20,000 mg/kg), copper (8,100 mg/kg), lead (7,600 mg/kg), and zinc (2,000 mg/kg). Dioxins/furans were also detected at a maximum concentration of 490 picograms per gram (pg/g) (Total tetrachlorodibenzo-furan [TCDF]). Also, potential OE impact was evaluated by USACE in its EE/CA report. This area will be further investigated for chemical impacts after OE clearance activities are completed.

**Demolition Site #1 - South Valley.** This area was identified as a potential ordnance open burn/open detonation (OB/OD) area because of the distribution of metal anomalies. No COIs related to site activities were detected at this site. Also, the USACE EE/CA report evaluated potential OE in this area. This area will be further investigated for chemical impacts after OE clearance activities are completed.

**Demolition Site #2 - South Valley.** No COIs related to site activities were detected at this site. In addition, because no physical evidence or ordnance-related activities were found at this site, the site was eliminated from further investigation.

**Demolition Site #3 - South Valley.** Physical evidence and geophysical studies indicate that this area was used to destroy ammunition by open burn/open detonation. The only COI related to site activities detected in shallow soil at Demolition Site #3 is mercury at a maximum concentration of 2.1 mg/kg. Also, the USACE EE/CA report evaluated potential OE at this area. This area will be further investigated for chemical impacts after OE clearance activities are completed.

**South Valley Wetland/Sediment - South Valley.** One metal related to site activities (i.e., mercury) was detected in the wetland sediment at a maximum concentration of 11.3 mg/kg. TNT and benzo(a)pyrene were also detected at maximum concentrations of 1.5 mg/kg and 0.094 mg/kg, respectively.

**Surface Water.** Surface water at the Project Site has not been impacted by site activities.

**Groundwater/Seeps.** Low concentrations of petroleum hydrocarbons (less than 210 µg/L) have been detected in groundwater samples collected from one well (MW-4A) in the North Valley. Low levels of explosive compounds (TNT, HMX, 2,4-DNT, 4amDNT, and amDNTs) have been detected in grab groundwater samples

and grab seep samples in the North Valley at a maximum concentration of 4.9 µg/L. One PAH (acenaphthylene) was detected in two of the three grab seep samples from the North Valley at less than 5.8 µg/L. One VOC (p-cymene [p-isopropyltoluene] at 0.61 µg/L), and one pesticide (p,p'-DDD at 0.0077 µg/L) were also detected in one of the North Valley grab seep samples.

One explosive compound (3-nitrotoluene) has been detected once in a groundwater sample collected from a well in the South Valley at a concentration of 0.59 µg/L. No explosive compounds were detected in this well during the recent (August 2000) groundwater sampling event, nor were explosives detected in the first monitoring event. The groundwater data from downgradient wells indicate that the low concentrations of explosives and dioxin associated with the unfiltered grab samples in the North Valley are a result of low levels of these compounds in sediment (turbidity) being detected. These low concentrations do not indicate dissolved chemicals in groundwater.

**Ridge Area Stockpiles.** Soil stockpiles brought to this area from off-site areas exhibit low levels of petroleum hydrocarbons (ranging from 7.7 mg/kg "J" to 53 mg/kg "J"), typical of soil handled by heavy earth-moving equipment.

**McAllister Drive Land Bridge.** The project records, including the review of aerial photographs, show that soil used to construct the McAllister Drive Land Bridge was obtained from a borrow area situated on the Ridge. Since the former Dynamite Burn Site was situated on the Ridge, soil from the Dynamite Burn Site would be in the lower portion of fill used to construct the land bridge. It is not known if the soil from the Dynamite Burn Site was chemically affected. Soil samples collected from three boreholes near the toe of the land bridge showed low levels of nitrate and nitrite ranging from 0.44 mg/kg to 1.2 mg/kg and from 0.038 mg/kg to 0.042 mg/kg, respectively.

**Off-Site Soil Issues.** In addition to the impacts listed above within the Project Site boundary, the RI/FS identified two potential off-site issues: (1) adjacent properties to the north and east of the TNT Strips, and (2) off-site fill areas.

All off-site TNT issues will be addressed through confirmation sampling, analysis, and risk assessment during the site remediation (see Table 8-1). If necessary, additional excavation of soils will be undertaken, as needed. A detailed sampling and analysis plan for confirmation sampling will be included in the non-OE Remedial Design Document (non-OE RDD) and all analyses performed will be summarized in a report of findings submitted for DTSC approval, prior to certification and closure of the Project Site.

On August 10, 2000, a Benicia resident reported to local authorities that he had encountered an ordnance-related item on his property. Granite's OE Specialist and USACE have inspected the item and have come to the following conclusions:

- The tail fin is from a mortar.
- The condition of the tail fin indicates that the mortar was destroyed by demolition.

- The mortar had not been fired as evidenced by the unpierced percussion primer at the base of the tail fin.
- Given that no firing ranges have been identified at the former Benicia Arsenal, the likely point of origin for the tail fin was an OB/OD site.
- The tail fin has been determined to be OE scrap.
- A total of 15 tail fins were found during the EE/CA investigation, 5 of which were recovered in Sector 3B (a portion of the Project Site) and 10 were recovered in Sector 5 (the Camel Barn area). USACE designated all these items as OE scrap.
- The tail fin is nonhazardous and does not pose a safety risk.
- There is currently no basis to believe that a dangerous condition exists at the residential lot.
- At this time, additional information is needed to assess the likelihood that OE items exist in areas that have previously received fill soils.

Discussions have occurred between DTSC, USACE, and Granite concerning future activities that are appropriate to address the off-site issue. The following three points have resulted from these discussions:

- During the clearance work to be conducted at the Project Site and the former Benicia Arsenal (the Gonzalves property), additional information regarding potential source areas and the distribution of OE and OE scrap will be obtained. This information, combined with existing information, will be evaluated by DTSC, USACE, and Granite and will be used to determine if further action is warranted.
- USACE is currently developing a Community OE Safety Program. The program focuses on educating the City of Benicia emergency staff on ordnance recognition, proper safety procedures and notification, community education through workshops for adults and children, fact sheets, and newsletters.
- The final site conceptual model will be based on data collected during the point clearance phase of the OE investigation and remediation at the Project Site, which is scheduled to begin in late fall 2001, and during the work at the former Benicia Arsenal, which began in May 2001. Evaluation of the data may be available in the first quarter of fiscal year 2002. Based on the final site conceptual model and consistent with USACE procedure, if DTSC determines that OE was distributed to residential areas outside the Project Site boundary and as a result there is risk that OE items can be encountered in a manner presenting a significant risk of injury or death, then concurrent with the areawide clearance phase of work activities, a plan will be developed in accordance with an order or agreement to identify and address these off-site areas. This plan will be presented to the public. If required, the plan will include an analysis of response alternatives for

these areas. Response alternatives may include the development of a Community Awareness Plan to educate the public, institutional controls, surface clearance of OE, and/or detection and clearance of OE to depth.

## **RISK ASSESSMENT**

A screening-level risk assessment was performed to assess the potential risks to human health and the environment associated with chemicals at the Project Site. This assessment was based on data collected during the RI. The results of the human health and ecological screening assessments were used to identify chemicals to be remediated. Remediation goals were proposed for these chemicals that are protective of both human and ecological receptors. A post-remediation risk assessment will be conducted to evaluate data from confirmation samples and non-remediated areas to ensure that the residual chemical concentrations are protective of human health and the environment.

### **Human Health Screening Assessment**

A Human Health Screening Assessment of current Project Site conditions was conducted separately for chemicals detected in soil in each area of interest and in groundwater and surface water in the North Valley or South Valley. This screening assessment was based on maximum-detected concentrations and readily available screening criteria (U.S. EPA Region IX Preliminary Remediation Goals [PRGs]) to rapidly screen detected chemicals against risk-based criteria to identify chemicals for which remediation goals will be developed. As such, the screening risk estimates are based on a hypothetical resident under current site conditions, and do not take into account that several areas of interest will never be used for residential purposes, and that much of the future residential area will be constructed on top of clean, imported fill material. Additionally, shallow groundwater at the Project Site is not currently used for any purpose, and is not expected to be used in the foreseeable future, due to limited groundwater occurrence and low formation permeability that does not yield sufficient quantities of water for drinking or irrigation purposes. Domestic water will be supplied to the residential development from other sources. Finally, surface water at the Project Site is limited to the wetland in the South Valley, which is outside the area to be developed for residential use. (Intermittent seeps are discussed within the context of groundwater samples.)

Estimated screening-level total excess cancer risks for chemicals detected in soil ranged from  $2 \times 10^{-2}$  to  $5 \times 10^{-7}$ , depending on the area of interest and whether the naturally occurring metal arsenic was included in the calculation. The estimated screening-level total non-cancer hazard indices ranged from 40 to 0.009, depending on the area of interest and whether the naturally occurring metals iron and manganese were considered in the calculation. Based on these results, several explosive compounds in the TNT Strips area: benzo(a)pyrene and dibenz(a,h)anthracene in stockpiles in the Ammunition Renovation/Primer Destruction Site or Howitzer Test Facility; and dioxins and furans, antimony, barium, copper, lead, and zinc in the Flare Site contributed most significantly to



the screening risk estimates. Soil remediation goals have been proposed for these chemicals in these areas. Although arsenic, iron, and manganese in some areas of interest contributed to risk estimates, further statistical analysis, cumulative probably plots, comparison to background literature values, and an evaluation of spatial distribution indicate that site soils do not appear to have been impacted by these chemicals. Therefore, no remediation of soils is proposed based on concentrations of arsenic, iron, or manganese at the Project Site. No other chemicals were detected in site soil at concentrations that would contribute significantly to potential health risks to future on-site residents.

Estimated screening-level total excess cancer risks for chemicals detected in groundwater or surface water ranged from  $4 \times 10^{-4}$  to  $1 \times 10^{-6}$ , and the estimated screening-level total non-cancer hazard indices ranged from 10 to 0.2. The majority of the chemicals that contributed most significantly to the screening risk estimates were metals that may be attributable to ambient conditions. The other chemicals were detected infrequently or only in grab groundwater samples. Based on downgradient well data and the nature of the compounds detected in the grab groundwater samples (relatively insoluble), it is concluded that the trace detections in grab groundwater samples are not representative of groundwater conditions at the Project Site. Based on these results, residual chemicals in groundwater and surface water do not appear to be of human health concern.

### **Ecological Screening Assessment**

An Ecological Screening Assessment of current Project Site conditions was conducted for chemicals detected in soil, surface water, or sediment in areas of the site where wildlife habitat will remain following post-grading and redevelopment activities (i.e., North Valley grassland, and South Valley freshwater marsh wetland and surrounding upland grassland areas). This screening assessment was based on a comparison of maximum-detected concentrations and ecological screening criteria for terrestrial, aquatic, or sediment-dwelling organisms to rapidly screen detected chemicals against risk-based criteria to identify chemicals for which remediation goals will be developed.

Several explosive compounds in soil at the TNT Strips; antimony, barium, copper, lead, and zinc in soil at the Flare Site; and mercury in soil at Demolition Site #3 were detected at concentrations greater than their respective soil screening criteria and found to warrant further consideration. Soil remediation goals have been proposed for these chemicals in these areas. The only chemical in surface water detected at concentrations greater than the water screening criteria was aluminum. Aluminum poses a threat to aquatic organism only in low pH and low hardness waters, whereas surface water in the wetland is believed to have a neutral pH (based on measurements of site groundwater) and hardness of approximately 400 milligrams per liter as  $\text{CaCO}_3$  (based on measurements of calcium and magnesium in surface water). Therefore, no remediation goal is proposed for aluminum in surface water.

With regard to sediment, copper, iron, manganese, and mercury were detected at concentrations above their respective screening criteria for sediment-dwelling

organisms. However, the exceedance of a screening criterion in sediment is insufficient evidence by itself to warrant remediation, and further evaluation of the available data indicates that (1) sediment does not appear to have been impacted by copper, (2) iron is normally present at percent levels and generally only bioavailable (and potentially toxic) in acidic (low pH) conditions, (3) the maximum-detected concentration of manganese in sediment is essentially equivalent to its sediment quality criterion, and other sediment samples contained manganese at concentrations well below the screening criterion, and (4) only three of ten surface sediment samples had mercury concentrations exceeding the screening criterion, the average mercury concentration in these samples is only slightly greater than the screening criterion, and a remediation goal will be established for mercury-affected soil upland of the South Valley wetland. Therefore, no remediation goal is proposed for copper, iron, manganese, and mercury in sediment.

Three of the chemicals in sediment were considered to be potentially bioaccumulative (benzo[b]fluoranthene, methyl mercury, and 2,4,6-trinitrotoluene). No relevant toxicity data were available for TNT and benzo(b)fluoranthene; however, these chemicals were found at low concentrations in sediment and below screening criteria for sediment-dwelling organisms. The maximum concentration of methyl mercury was below its screening criterion indicating that the risk of bioaccumulation from sediment is negligible. Therefore, no remediation goals were proposed for these chemicals in sediment.

### **Soil Remediation Goals**

Soil remediation goals were developed for specific chemicals in specific areas that may pose a potential risk to human health under the conservative baseline residential conditions or a potential risk to ecological receptors using conservative ecological screening criteria. The proposed soil remediation goals for the identified metals are the calculated upper tolerance limit (UTL) of the ambient soil samples. These concentrations are protective of both human and ecological receptors. The proposed soil remediation goal for dioxins and furans is based on ambient concentrations, whereas the proposed remediation goal for the PAHs is non-detect. Although not necessary to protect human health or the environment, a soil remediation goal was proposed for TPH based on California Regional Water Quality Control Board risk-based screening levels for protection of groundwater (1995). Finally, the proposed soil remediation goals for explosive compounds were based on the lowest risk-based levels calculated for protection of human and ecological receptors.

Table ES-1 provides the soil remediation goals that have been established to satisfy the remedial action objectives (RAOs) for the Project Site.

### **Post-Remediation Risk Assessment**

A post-remediation risk assessment will be conducted to ensure that the residual chemical concentrations are protective of human health and the environment. This assessment will be based on data collected from confirmation samples and in areas that were not remediated, and will be completed in accordance with standard state and federal guidance for baseline risk assessments. The post-

**Table ES-1. Soil Remediation Goals**

	Remediation Goal	Area of Cleanup
<b>Metals in Soil</b>		
Antimony	2.84 mg/kg	Flare Site
Barium	642 mg/kg	Flare Site
Copper	87.7 mg/kg	Flare Site
Lead	148 mg/kg	Flare Site
Mercury	0.77 mg/kg	Demolition Site #3
Zinc	142 mg/kg	Flare Site
<b>Organic Compounds in Soil</b>		
Dioxins	12 pg/g <sup>(a)</sup>	Flare Site
2,4,6-TNT	16 (residential) mg/kg <sup>(b)</sup>	TNT Strips
2,4,6-TNT	53 (recreational) mg/kg <sup>(b)</sup>	TNT Strips
2,6-DNT	non-detect (PQL = 0.5 mg/kg) <sup>(c)</sup>	TNT Strips
benzo(a)pyrene	non-detect (PQL = 0.03 mg/kg) <sup>(c)</sup>	Ammunition Renovation/Primer Destruction Site - Stockpiles #1 and #2
dibenz(a,h)anthracene	non-detect (PQL = 0.05 mg/kg) <sup>(c)</sup>	Howitzer Test Facility - Stockpile #3
TPHs	500 (residential) mg/kg <sup>(d)</sup>	Areas to be determined based on potential UST

Notes: (a) Dioxin concentrations are expressed in terms of 2,3,7,8-TCDD TEQ.

(b) Individual remediation goals for all other explosives detected in soils have not been proposed. This decision is based on cumulative risks indicating that explosive compounds are likely to be below de minimus risk levels if TNT and 2,6-DNT are removed to remedial goals.

(c) Goals are estimated PQL values. Because these are laboratory-specific numbers, they may change once the laboratory for the remedial action phase has been selected. DTSC will be notified if there are changes in the PQL from the values noted.

(d) This value will be used as a basis for remediation of the North Valley.

DNT = dinitrotoluene

DTSC = Department of Toxic Substances Control

mg/g = milligrams per gram

pg/g = picograms per gram

PQL = Practical Quantitation Limit

TCDD = tetrachlorodibenzo-p-dioxin

TEQ = Toxicity Equivalence

UST = underground storage tank

remediation risk assessment will be used to help identify any additional areas requiring evaluation, if necessary, and to identify the final clean-up levels for the Project Site that are protective of human health and ecological impacts.

## **REMEDIAL INVESTIGATION AND RISK ASSESSMENT RECOMMENDATIONS AND CONCLUSIONS**

Based on the risk analysis documented in Chapter 7.0, the following conclusions and recommendations are made about the sites.

### **Sites Requiring Remediation or Further Investigation**

**TNT-Strip Areas.** Detected concentrations of TNT and associated explosive compounds were determined to exceed human and ecological screening criteria. This site is recommended for remediation. Additional extent and confirmation sampling is proposed to define the lateral and vertical extent of soils requiring remediation.

**Howitzer Test Facility and Stockpile #3.** Detected concentrations of dibenz(a,h)anthracene exceed human health screening criteria in Stockpile #3. It is planned to remove the stockpiled material from the sites for appropriate disposal at an off-site facility. Confirmation sampling beneath the stockpile will be conducted following removal to verify that all impacted soil has been removed. No further action is recommended for the remainder of the Howitzer Test Facility.

**Ammunition Renovation/Primer Destruction Site and Stockpiles #1 and #2.** Detected levels of benzo(a)pyrene exceed human health screening criteria in Stockpiles #1 and #2. It is planned to remove the stockpiled material from the site for appropriate disposal at an off-site facility. Confirmation sampling beneath the stockpiles will be conducted following removal to verify that all impacted soil has been removed. No further action is recommended for the remainder of the Ammunition Renovation/Primer Destruction Site, except for the area where the UST investigation will occur.

**Flare Site.** Detected concentrations of antimony, barium, copper, lead, and zinc exceeded human health and ecological screening criteria and dioxin levels also exceeded human health screening criteria. This site is recommended for remediation.

**Demolition Site #1.** Based on sampling to date, detected concentrations of COIs at Demolition Site #1 do not exceed human or ecological screening criteria, and no further action is required. Because geophysical anomalies prevented complete characterization of the site, additional sampling will be conducted during the OE point clearance activities, and the data will be included in the post-remediation risk assessment.

**Demolition Site #3.** Detected concentrations of mercury did not exceed human health screening criteria but did exceed ecological screening criteria. This site is recommended for remediation.

**Ridge Area Stockpiles.** Low concentrations of oil were detected below human health and ecological screening criteria. Additional testing is proposed during

remediation to assess if the stockpiled soils can be used as fill in the North Valley or must be hauled off site to a suitable landfill.

**McAllister Drive Land Bridge.** Based on sampling to date at the McAllister Drive Land Bridge, detected concentrations of chemicals do not exceed human health screening criteria. At the request of DTSC, additional characterization of the McAllister Drive Land Bridge will be conducted.

**Groundwater, Seeps and Surface Water.** The maximum concentrations of three detected metals in groundwater exceeded human health screening criteria based on the ingestion of groundwater. Groundwater is not currently used for any purpose and is not expected to be used in the foreseeable future because of the limited amount of groundwater available. General water quality will continue to be evaluated at the site through a focused groundwater monitoring program. No impact to surface water was identified in the South Valley and no further action is recommended.

#### **Sites Requiring No Further Action**

**North Valley Landfill.** Chemicals detected in the North Valley Landfill do not exceed human health screening criteria, and the screening-level risk estimates were near "J" or below benchmark levels of  $1 \times 10^{-6}$  or an HI of 1. No further action is recommended.

**Dynamite Burn Site.** No COIs were identified at the Dynamite Burn Site and no further action is recommended.

**Demolition Site #2.** No evidence DOD of activities was found at this site and it was eliminated from further investigation.

#### **FEASIBILITY STUDY**

An FS was completed to identify a range of alternatives to remediate OE and chemically affected soil and address groundwater at the Project Site. The FS utilized data and analyses generated as part of the RI and screening-level Health Risk Assessment to develop potential alternatives for COIs in soil.

The FS process was completed in accordance with U.S. Environmental Protection Agency (EPA) guidance (1988), the National Contingency Plan (EPA, 40 Code of Federal Regulations Part 300), and the California Environmental Quality Act (CEQA). This process included the identification and screening of remedial technologies and process options, and the development, screening, and analysis of comprehensive alternatives to meet the RAOs and other regulatory requirements.

A total of 13 potential alternatives were initially considered in the FS. These alternatives were screened to focus on those alternatives with the greatest potential to remediate the Project Site. In addition, the No-Action/No Project alternative was evaluated and retained, in accordance with EPA and CEQA guidelines.

Portions of the Project Site are zoned for residential use. Accordingly, only remedial alternatives consistent with residential standards were carried through the full evaluation process in the FS.

The following eight alternatives were carried forward for detailed analysis:

**Alternative 1.** No-Action.

**Alternative 2.** Institutional Controls and Monitoring

**Alternatives 5A and 5B.** OE point clearance over the entire Project Site; areawide OE clearance in the North Valley and Ridge areas having a potential for containing OE and intended for future residential use, as well as overburden soil and soil fill associated with Unit D-1 lots; excavation, treatment, and disposal of chemically affected soil above RAOs; installation of a layer of crushed bedrock in future residential areas; and institutional controls and monitoring.

**Alternatives 6A and 6B.** Include Alternative 5 components plus the excavation of the South Valley potentially OE-impacted soil and placement in the North Valley and adjacent to the South Valley wetlands; with additional geophysical scanning of potentially OE-impacted soil in lifts during placement.

**Alternatives 8A and 8B.** Include Alternative 5 components plus the excavation of the South Valley potentially OE-impacted soil and replacement in the South Valley; with additional geophysical scanning of potentially OE impacted soil in lifts during placement in South Valley.

Alternatives 5A, 6A, and 8A include testing of soils during remedial activities and treatment by homogenization of soils containing TNT concentrations greater than 10 percent to levels acceptable for off-site transport and disposal. Alternatives 5B, 6B, and 8B include composting to treat soil containing TNT to nonhazardous levels acceptable for off-site transport and disposal. If treated soil meets all RAOs, it may be left on site.

The above alternatives were evaluated in detail, in accordance with the nine criteria specified in the National Oil and Hazardous Substance Pollution Contingency Plan and EPA guidance. Alternatives 1 and 2 would not satisfy the RAOs or provide long-term permanent remedies for OE and chemically affected soils at the Project Site. Alternatives 5, 6, and 8 would achieve the RAOs and effectively remediate the Project Site. These alternatives would remediate all areas of interest.

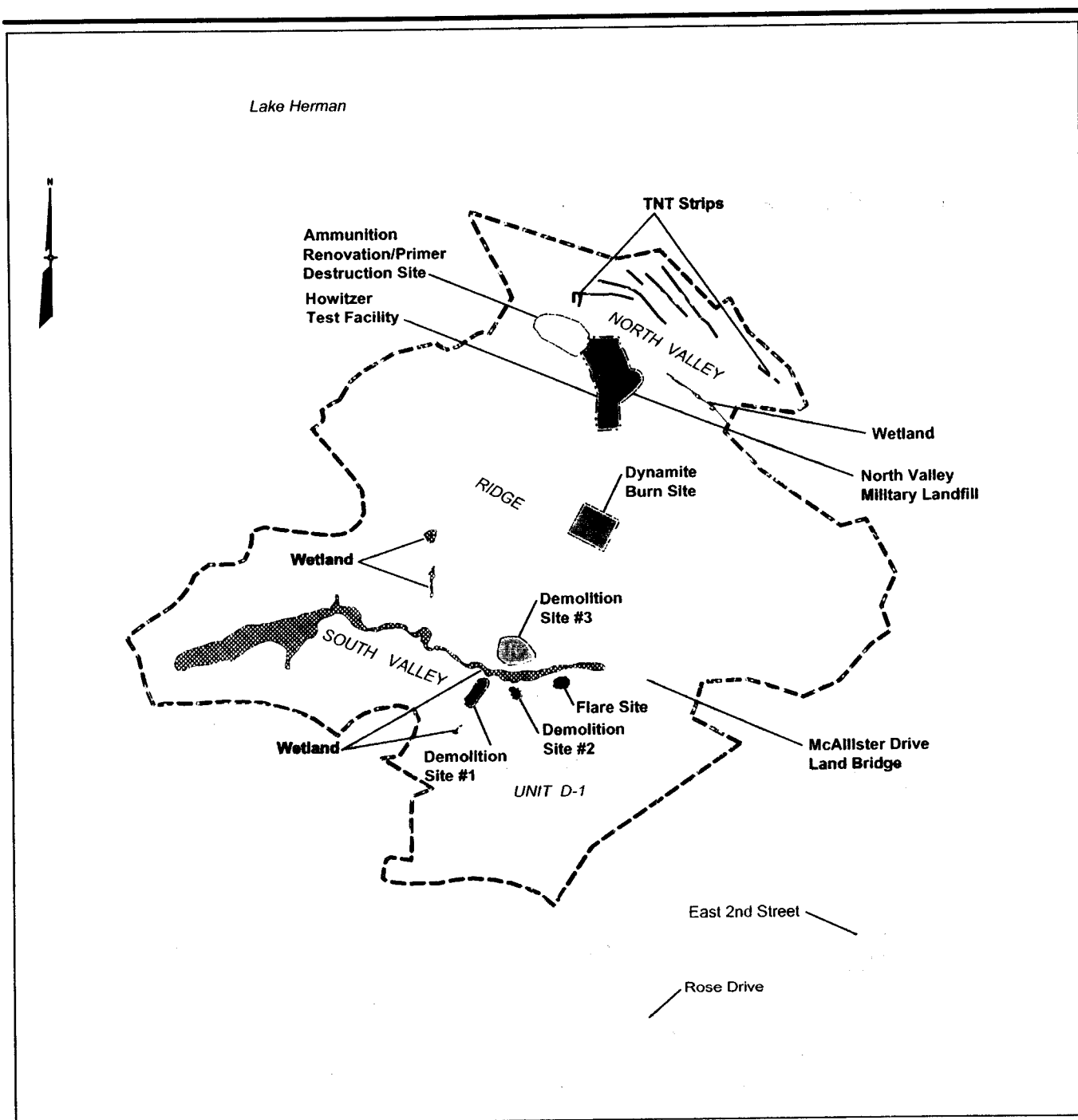
Alternatives 5, 6, and 8 vary primarily with respect to the location and quantity of soil in the South Valley that would be remediated for OE using areawide clearance procedures. There would be potential short-term impacts for all alternatives related to excavation and construction activities, and implementation of a minimum separation distance when remediating the Project Site for OE.

Alternative 5A is the recommended alternative, since this alternative is OE protective, reduces the environmental and aesthetic impacts to the South Valley, includes point clearance and areawide clearance in residential areas having a potential for containing OE, and includes removal and disposal of chemically affected soil exceeding RAOs. Future residential areas would be founded on bedrock. Soils removed through areawide clearance would be covered with 14 feet

of OE-free crushed bedrock or with a minimum of 4 feet of crushed bedrock and underlain by bedrock, following placement of areawide clearance soil in the North Valley. Institutional controls would be applied to limit future excavation in the paved portions of the McAllister Drive Land Bridge and Unit D-1 paved areas, as well as in the North Valley and South Valley. After remediation, additional groundwater monitoring wells would be installed at the east and west ends of the North Valley and at the east end of the South Valley to monitor groundwater in the alluvium and bedrock. In addition, water quality sampling would be performed for a specified period on water from the North Valley subdrain system and any surface water and seeps in the North Valley and South Valley.

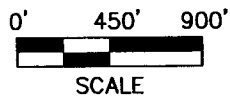
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#### EXPLANATION

----- Project Site Boundary



Note: Contour interval equals 25 feet.

**FINAL**

**Figure ES-1  
Project Site Layout Map**

**Tourtelot Cleanup Project  
Benicia, California**

**July 2001**

